CLAIMS

1. A method for tracking an object, comprising:

positioning a radio frequency (RF) driver to radiate an RF driving field toward the object;

fixing to the object a wireless transponder comprising a power coil and at least one sensor coil;

receiving the RF driving field using the power coil and storing electrical energy derived therefrom;

driving a plurality of field generators to generate electromagnetic fields at respective frequencies in a vicinity of the object that induce a voltage drop across the at least one sensor coil;

generating a digital output signal at the wireless transponder indicative of the voltage drop across the sensor coil, and powering the generation of the digital output signal using the stored electrical energy;

transmitting the digital output signal from the wireless transponder using the power coil, and powering the transmission of the digital output signal using the stored electrical energy; and

receiving and processing the digital output signal to determine coordinates of the object.

2. A method according to claim 1, wherein driving the plurality of field generators comprises driving the plurality of field generators to generate the electromagnetic fields at different respective frequencies, and wherein the voltage drop across the at least one sensor coil has frequency components at the different respective frequencies of the plurality of field generators.

3. A method according to claim 1, comprising inserting the transponder, together with the object, into a body of a subject, wherein positioning the plurality of field generators and the RF driver comprises placing the plurality of field generators and the RF driver outside the body.

4. A method according to claim 1, comprising inserting the transponder, together with the object, into a body of a subject during a medical procedure, and removing the transponder from the body of the subject during the medical procedure.

5. A method according to claim 1, wherein the object includes an elongate probe, for insertion into a body of a subject, and wherein fixing the transponder to the object comprises fixing the transponder in the probe, and wherein receiving and processing the digital output signal comprises determining the coordinates of a distal end of the probe in the body.

6. A method according to claim 1, wherein generating the digital output signal comprises operating the transponder powered solely by the electrical energy derived from the RF driving field by the power coil.

7. A method according to claim 1,

wherein receiving the RF driving field comprises receiving the RF driving field: (a) during a first time period, prior to driving the plurality of field generators, and (b) during a second time period, subsequent to the first time period and prior to transmitting the digital output signal,

wherein storing the electrical energy derived from the RF driving field comprises storing first electrical energy during the first time period and storing second electrical energy during the second time period,

wherein powering the generation of the digital output signal comprises powering the generation of the digital output signal using the first stored electrical energy, and

wherein powering the transmission of the digital output signal comprises powering the generation of the digital output signal using the second stored electrical energy.

8. A method according to claim 1,

wherein receiving the RF driving field comprises receiving the RF driving field during a time period prior to driving the plurality of field generators,

wherein storing the electrical energy comprises storing the electrical energy during the time period,

wherein powering the generation of the digital output signal comprises powering the generation of the digital output signal using the electrical energy stored during the time period, and

wherein powering the transmission of the digital output signal comprises powering the transmission of the digital output signal using the electrical energy stored during the time period.

9. A method according to claim 1, wherein generating the output signal comprises:

measuring signal components of the voltage drop; and

converting the components into digital values.

10 A method according to claim 9, wherein measuring the signal components comprises measuring an amplitude and a phase.

11. A method according to claim 1,

wherein the object includes an implant for implantation in a body of a subject,

wherein fixing the transponder to the object comprises fixing the transponder to the implant, and

wherein receiving and processing the digital output signal comprises determining the coordinates of the implant within the body.

12. A method according to claim 11,

wherein the implant includes a joint implant, including a first joint portion and a second joint portion that articulates therewith,

wherein fixing the transponder comprises fixing a plurality of transponders respectively to the first joint portion and the second joint portion, and

wherein determining the coordinates of the implant comprises determining a distance between the first joint portion and the second joint portion responsive to digital output signals from the transponders.

13. A method according to claim 12, wherein determining the distance comprises finding the distance using the transponders during both intraoperative and post-operative periods.

14. A method for tracking an object, comprising:

radiating a radiofrequency (RF) driving field toward the object;

receiving the RF driving field at the object, and storing electrical energy derived therefrom;

subsequently to storing the electrical energy, generating a plurality of electromagnetic fields at respective frequencies in a vicinity of the object;

using the stored electrical energy, generating a digital output signal indicative of respective strengths of the electromagnetic fields at the object;

transmitting the digital output signal from the object; and

receiving and processing the digital output signal to determine coordinates of the object.

15. A method according to claim 14, wherein generating the digital output signal comprises generating the digital output signal solely using the stored electrical energy derived from the RF driving field.

16. A method according to claim 14,

wherein receiving the RF driving field comprises receiving the RF driving field: (a) during a first time period, prior to generating the plurality of electromagnetic fields, and (b) during a second time period, subsequent to the first time period and prior to transmitting the digital output signal,

wherein storing the electrical energy derived from the RF driving field comprises storing first electrical energy during the first time period and storing second electrical energy during the second time period,

wherein generating the digital output signal comprises generating the digital output signal using the first stored electrical energy, and

wherein transmitting the digital output signal comprises transmitting the digital output signal using the second stored electrical energy.

17. A method according to claim 14,

wherein receiving the RF driving field comprises receiving the RF driving field during a time period prior to generating the plurality of electromagnetic fields,

wherein storing the electrical energy comprises storing the electrical energy during the time period,

wherein generating the digital output signal comprises generating the digital output signal using the electrical energy stored during the time period, and

wherein transmitting the digital output signal comprises transmitting the digital output signal using the electrical energy stored during the time period.

18. A method for tracking an object, comprising:

radiating a radiofrequency (RF) driving field toward the object;

receiving the RF driving field at the object, and storing electrical energy derived therefrom;

subsequently to storing the electrical energy, generating a plurality of electromagnetic fields at respective frequencies in a vicinity of the object;

using the stored electrical energy, generating an output signal indicative of respective strengths of the electromagnetic fields at the object;

transmitting the digital output signal from the object; and

receiving and processing the digital output signal to determine coordinates of the object.

19. A method according to claim 18, wherein generating the output signal comprises generating a digital output signal.

20. A method according to claim 18, wherein generating the output signal comprises generating an analog output signal.

21. Apparatus for tracking an object, comprising:

(a) a radio frequency (RF) driver, adapted to radiate an RF driving field toward the object;

(b) a plurality of field generators, adapted to generate electromagnetic fields at respective frequencies in a vicinity of the object;

(c) a wireless digital transponder, fixed to the object, the transponder comprising:

a power coil, coupled to receive the RF driving field;

a power storage device, adapted to store electrical energy derived from the RF driving field;

at least one sensor coil, coupled so that a voltage drop is induced across the at least one sensor coil responsive to the electromagnetic fields; and

a control circuit, coupled to the at least one sensor coil and to the power storage device, and adapted to use the stored electrical energy to generate a digital output signal indicative of the voltage drop and adapted to use the stored electrical energy to drive the power coil to transmit the digital output signal; and

(d) a signal receiver, adapted to receive the digital output signal transmitted by the power coil and, responsive thereto, to determine coordinates of the object.

22. Apparatus according to claim 21,

wherein the power storage device is adapted to store first electrical energy derived from the RF driving field during a first time period,

wherein the control circuit is adapted to use the first stored electrical energy to generate the digital output signal,

wherein the power storage device is adapted to store second electrical energy derived from the RF driving field during a second time period, following the first time period and following the generating by the control circuit of the digital output signal, and

wherein the control circuit is adapted to use the second stored electrical energy to drive the power coil to transmit the digital output signal.

23. Apparatus according to claim 21, wherein the plurality of field generators are adapted to generate the electromagnetic fields at different respective frequencies.

24. Apparatus according to claim 21, wherein the control circuit is adapted to operate powered solely by the electrical energy conveyed thereto by the power coil.

25. Apparatus according to claim 21, wherein the voltage drop across the at least one sensor coil has frequency components at the different frequencies of the plurality of field generators, and wherein the digital signal

generated by the control circuit is indicative of the frequency components of the voltage drop.

26. Apparatus according to claim 21, wherein the control circuit is adapted to generate the digital output signal indicative of an amplitude of the voltage drop and a phase of the voltage drop, and wherein the signal receiver is adapted to determine the coordinates and an orientation of the object, responsive to the amplitude and the phase of the voltage drop indicated by the digital output signal.

27. Apparatus according to claim 21, wherein the power storage device comprises a capacitor.

28. Apparatus according to claim 27, wherein the capacitor has a capacitance between about 5 and 20 microfarads.

29. Apparatus according to claim 21, wherein the object comprises an implant, and wherein the transponder is fixed in the implant so as to enable the signal receiver to determine the coordinates of the implant within the body.

30. Apparatus according to claim 29,

wherein the implant comprises a joint implant, comprising a first joint portion and a second joint portion for articulation therewith,

wherein the transponder comprises a plurality of transponders fixed respectively to the first joint portion and the second joint portion, and

wherein the signal receiver is adapted to determine a distance between the first joint portion and the second

joint portion responsive to the output signal from the transponders.

31. Apparatus according to claim 30, wherein the first joint portion comprises a femur head and wherein the second joint portion comprises an acetabulum.

32. A wireless position transponder for operation inside a body of a subject, the transponder comprising:

at least one sensor coil, coupled so that a voltage drop across the at least one sensor coil is induced responsive to one or more electromagnetic fields applied to the body in a vicinity of the transponder;

an arithmetical logic unit (ALU), coupled to the at least one sensor coil so as to generate a digital output signal indicative of the voltage drop across the at least one sensor coil, such that the digital output signal is indicative of coordinates of the transponder inside the body; and

a power coil, adapted to receive a radio frequency (RF) driving field applied to the body in the vicinity of the transponder, and coupled to convey electrical energy derived from the driving field to the ALU, and further coupled to transmit the digital output signal generated by the ALU so that the signal can be received by processing circuitry outside the body for use in determining the coordinates.

33. A transponder according to claim 32, comprising a power storage device, adapted to store the electrical energy conveyed by the power coil, and to convey the stored electrical energy to the ALU, wherein the ALU is adapted to use the electrical energy conveyed thereto by

the power storage device to power the generation of the digital output signal and to power the transmission of the digital output signal.

34. A transponder according to claim 33, wherein the power storage device comprises a capacitor.

35. A transponder according to claim 32, wherein the ALU is adapted to generate the digital output signal to be indicative of an amplitude and a phase of the voltage drop across the at least one sensor coil.